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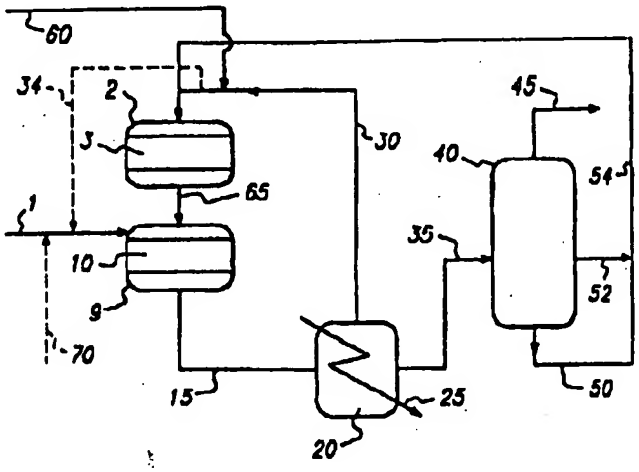
(54) Title: PROCESS FOR REVERSE STAGING IN HYDROPROCESSING REACTOR SYSTEMS



(57) Abstract

A hydrocarbon feed (1) is passed to a denitrification and desulfurization zone (10); passing said denitrification and desulfurization zone effluent to a purification/cooling zone (20) for removal of NH_3 and H_2S and cooling, and recovering from said purification/cooling zone a hydrogen/light hydrocarbon stream (30) and a liquid stream containing dissolved gases (35); passing said liquid stream containing dissolved gases to a separation zone (40) and recovering a light product (45), a liquid bottoms (50), and at least one side-cut product therefrom (52); passing said liquid bottoms (50) and said side-cut (52) product and said hydrogen/light hydrocarbon stream from step (30) (b) to a hydrocracking or a hydrotreating zone; passing said hydrocracking or hydrotreating zone effluent (65) to said denitrification and desulfurization zone (10).

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(b) reprocessing the undesirable products in a separate reaction loop. Typical approaches in the art to selective hydrotreating of specific boiling range products include (a) overtreating of the entire feed to the point where the most difficult product specification is met, or (b) treating of the whole feed to a lesser extent followed by a separate hydrotreating of particular product cuts to meet the most difficult specifications.

It would be desirable to have a hydroprocessing process which achieved higher conversion or deeper treating processing while avoiding the drawbacks of known processes.

III. SUMMARY OF THE INVENTION

The present invention serves to accomplish these objectives in a single reaction loop including lower costs than multiple loops, while maintaining the advantages of a multiple loop system including higher reaction rates or catalysts tailored for pretreated feeds.

The present invention includes a process for reverse staging to obtain high conversion, selective hydrotreating and product selectivity in a hydroprocessing reactor system including performing in a single reactor loop a higher conversion or deeper treating processing in a top bed(s) of a reactor or in the lead reactor in a series reactor loop and performing the general feed processing in the reactor zones that follow.

IV. BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts one embodiment of a flow diagram of the process of the invention utilizing a common vessel for housing the different treatment zones.

The liquid stream containing dissolved gases is passed to a separation zone. Any conventional separation may be used, typically distillation. A light product and other fractions selected from a liquid bottoms, one or more side- or mid-cuts, and mixtures thereof, are recovered. The other fractions, i.e., liquid bottoms and/or one or more side- or mid-cuts, are passed to a second hydrotreating zone, e.g., a hydrocracking zone. There, at hydrocracking conditions, the liquid bottoms and/or one or more side- or mid-cuts are contacted with a hydrocracking catalyst. A hydrocracking zone effluent is then recovered. The hydrocracking zone effluent is then passed to the first hydrotreating zone, in one embodiment, a denitrification and desulfurization zone.

The use of the two reaction zones can be varied in this invention. That is, the first and second hydrotreating or reaction zone may each be a hydrocracking zone or a denitrification and desulfurization zone. In one embodiment of the invention, the lower zone which the fresh feed first contacts is a denitrification and desulfurization zone. The upper feed is a hydrocracking zone. In another embodiment, the reverse is true. Alternatively, each zone may both be either a hydrocracking zone or each a denitrification and desulfurization zone. Each may also be a combination or mixture of a hydrocracking zone and a denitrification and desulfurization zone.

B. Advantages of Process of the Invention

The present invention provides a single reaction loop. This single reaction loop method lowers costs as compared to the use of multiple reaction loops. Yet, the single reaction loop of the invention maintains the advantages of higher reaction rates or catalyst tailored for pretreated feeds of a multiple reaction loop system. The present invention accomplishes the final processing in the upper reaction zone or top bed or beds of a reactor or

In an optional embodiment in the case of residuum processing, the present process can also provide benefits in the lower reaction zones which includes reduced pulsation tendency.

C. Feedstocks and Products

Feedstocks suitable for use in the invention and desired products obtained include any conventional or known hydrocracking/hydroprocessing feedstocks and products. The feedstocks and desired products for the instant process include those disclosed in U.S. Patent Nos. 5,277,793; 5,232,577; 5,073,530; 4,430,203; and 4,404,088 which are incorporated herein by reference. In one preferable embodiment, the hydrocarbon feed is selected from a residuum, a vacuum gas oil, middle-distillates, and mixtures thereof.

D. Reaction Conditions and Catalysts

Suitable hydrocracking and hydroprocessing catalysts and reaction conditions include any conventional or known catalysts and reaction conditions. The catalysts and reaction conditions suitable for the instant process include those disclosed in U.S. Patent Nos. 5,277,793; 5,232,577; 5,073,530; 4,430,203; and 4,404,088 which are incorporated herein by reference. Where the reaction zone is a denitrification and/or desulfurization zone, the contacting occurs at denitrification and/or desulfurization conditions. Where the reaction zone is a hydrocracking zone, the contacting occurs at hydrocracking conditions.

When the above-described process is used to hydrotreat feedstocks to remove sulfur and nitrogen impurities, the following process conditions will typically be used: reaction temperature, 400°F-900°F; pressure, 500 to

A. Figure 1

As illustrated in the flow diagram of FIG. 1, the catalytic reactions used in this process are accomplished in two reaction zones 3 and 10. Vessel 2 houses both reaction zones 3 and 10. The initial processing is carried out in the second zone 10 and the high conversion processing carried out in the first zone 3. The flow scheme optionally includes other features which are common in hydroprocessing units such as preheating of liquid and gas feeds to the reactors (preheaters not shown), NH_3 and H_2S removal and effluent cooling and separation zone 20, optional recycle gas purification zone 31, and recirculation streams 30 and 32, and product separation and distillation zone 40. Liquid bottoms stream 50, and/or side- or mid-cut 52, from distillation zone 40 are joined as stream 54. Stream 54 is passed to reaction zone 3. Make-up hydrogen stream 60 is added to gas recirculation stream 32 (also termed "hydrogen/light hydrocarbon stream 30" or "H_2S removal zone effluent 32"). Alternatively, make-up hydrogen stream 70 is added to feed stream 1 instead of, or in addition to, adding make-up hydrogen to stream 32.

Hydrocracking or deeper hydrotreating takes place in reaction zone 3 depending on the type of catalyst used in that zone. The effluent 65 from reaction zones passes to reaction zone 10. Fresh feed 1 is introduced at an intermediate point between reactor beds 3 and 10. It is processed in the presence of the effluent 65 from the upper reaction zone 3. Effluent 65 assists in distribution of feed stream 1 through reaction zone 10. Effluent 65 also acts as a heat-sink for the exothermic reaction in reaction zone 10.

The effluent 15 from the lower zone 10 is treated for NH_3 and H_2S removal in zone 20. Conventional methods, typically water washing, is utilized for the NH_3 and H_2S removal. Zone 20 is also a cooling and separation zone producing a gas stream 30 and a liquid stream containing dissolved

VII. CLAIMS

WHAT IS CLAIMED IS:

1. A method of reverse stage hydrotreating a hydrocarbon feed to obtain high conversion, selective hydrotreating and product selectivity in a hydroprocessing reactor system, said method comprising:

a. Passing a hydrocarbon feed selected from a residuum, a vacuum gas oil, middle distillate, and mixtures thereof to a denitrification and desulfurization zone; contacting said hydrocarbon feed at a temperature of about 400°F to about 900°F; a pressure of about 500 psig to about 5000 psig; a flow rate of about 0.5 LHSV to about 20 LHSV; and an overall hydrogen consumption of about 300 to about 2000 scf per barrel of liquid hydrocarbon feed, with a denitrification and desulfurization catalyst; and recovering a denitrification and desulfurization zone effluent therefrom;

b. Passing said denitrification and desulfurization zone effluent to a purification/cooling zone for removal of NH_3 and H_2S and cooling, and recovering from said purification/cooling zone a hydrogen/light hydrocarbon stream and a liquid stream containing dissolved gases;

c. Passing said liquid stream containing dissolved gases to a separation zone and recovering a light product, a liquid bottoms, and at least one side-cut product therefrom;

d. Passing said liquid bottoms and said side-cut product and said hydrogen/light hydrocarbon stream from step (b) to a hydrocracking zone; contacting said liquid bottoms and said

d. Passing said liquid stream containing dissolved gases to a separation zone.

5. The process of claim 3 wherein said general feed is selected from a residuum, a vacuum gas oil, a middle distillate, and mixtures thereof; and further comprising passing said hydrogen/light hydrocarbon stream in step (b) to a H_2S removal zone prior to passing to said upper reaction zone or lead reactor in step (c).

6. The process of claim 4 wherein said reactor zones that follow are hydrocracking zones and comprise a hydrocracking catalyst and wherein said hydrocracking zones have a temperature of about 400°F to about 950°F; a pressure of about 500 psig to about 5000 psig; a flow rate of about 0.1 LHSV to about 15 LHSV; and an overall hydrogen consumption of about 500 to about 2500 scf per barrel of liquid hydrocarbon feed.

7. The process of claim 5 wherein said reactor zones that follow are denitrification and desulfurization zones and said process further comprises contacting in said denitrification and desulfurization zones a denitrification and desulfurization catalyst with a general feed selected from residuum, a vacuum gas oil, middle distillates, and mixtures thereof, at a temperature of about 400°F to about 900°F; a pressure of about 500 psig to about 5000 psig; a flow rate of about 0.5 LHSV to about 20 LHSV; and an overall hydrogen consumption of about 300 to about 2000 scf per barrel of liquid hydrocarbon feed, and further comprises recovering a denitrification and desulfurization zone effluent.

b. Passing said liquid stream containing dissolved gases to a separation zone and recovering a light product, a liquid bottoms, and at least one side-cut product therefrom; and

c. Passing said liquid bottoms and said side-cut product and said hydrogen/light hydrocarbon stream from step (b) to said upper reaction zone.

12. A method of processing a hydrocarbon feed comprising:

a. Passing a hydrocarbon feed to a second hydrotreating zone, contacting at hydrotreating conditions said hydrocarbon feed with a second hydrotreating catalyst, and recovering a second hydrotreating zone effluent therefrom;

b. Passing said hydrotreated product to a vapor-liquid separation zone, and recovering therefrom a light product and other fractions selected from a liquid bottoms, one or more middle cuts, and mixtures thereof;

c. Passing said other fractions to a first hydrotreating zone, contacting at hydrotreating conditions said hydrocarbon feed with a first hydrotreating catalyst, and recovering a first hydrotreating zone effluent therefrom; and

d. Passing said first hydrotreating zone effluent to said second hydrotreating zone.

13. The process of claim 12 further comprising feeding make-up hydrogen to said second hydrotreating zone.

14. The process of claim 12 further comprising:

18. The process of claim 12 wherein said first hydrotreating zone is a hydrocracking zone having a temperature of about 400°F to about 950°F; a pressure of about 500 psig to about 5000 psig; a flow rate of about 0.1 LHSV to about 15 LHSV; and an overall hydrogen consumption of about 500 to about 2500 scf per barrel of liquid hydrocarbon feed, and wherein said first hydrotreating catalyst comprises a hydrocracking catalyst.

19. The process of claim 12 wherein said first hydrotreating zone is a denitrification and desulfurization zone.

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